UDC 666.112.7:620.193.2:669.14.8

IMPROVEMENT OF PROTECTIVE PROPERTIES OF BOROSILICATE MELT BY INTRODUCING DEOXIDIZERS

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Translated from Steklo i Keramika, No. 9, pp. 9 – 10, September, 2004.

The possibilities of improving the protective properties of borosilicate melts by adding deoxidizers are considered. The dependence of the rate of oxidation of steel 30KhGSA on Fe_2O_3 content in the melt is experimentally established. The rate of oxidation of steel 30KhGSA in a melt deoxidized by silicon carbide, silicon nitride, and by a boron-bearing product are determined.

The deciding role in the oxidation of metal under a layer of borosilicate glass in air belongs to heterovalent metal ions [1], therefore, the protective properties of glass can be substantially improved by introducing a deoxidizing agent, which reduces Fe_2O_3 that is the main oxidizer in the solution to FeO or to Fe.

Deoxidizing agents can be chosen from reducers which have little effect on viscosity, do not cause crystallization of glass, and do not modify the composition of the surface layer of metal, such as silicon carbide and nitride, or boron-bearing products, in particular the boron product in which the content of elementary boron reaches 13%.[2]

The oxidation of steel 30KhGSA was investigated by the derivatographic method [2] in borosilicate melts with different contents of Fe_2O_3 and deoxidizers at a temperature of 1273 K. The compositions of the analyzed glasses are given in Table 1.

Figure 1 represents the oxidation curves of steel 30KhGSA in melt 1 containing 3, 5, and 10% Fe_2O_3 and deoxidized by 2% silicon carbide, silicon nitride, or the boron agent. It can be seen that the quantity of oxidized metal after introducing deoxidizers decreases by half, to one-fourth, and one-seventh, respectively. It follows from the above data that the optimum deoxidizing properties are found in the boron-bearing product and silicon nitride.

The decreased amount of oxidized metal is due to a decreasing quantity of the oxidizer in the melt, which reacts with the deoxidizer according to the following reactions:

$$4Fe_2O_3 + SiC = CO_2 + SiO_2 + 8FeO;$$

$$4Fe_2O_3 + SiN = NO_2 + SiO_2 + 8FeO;$$

$$3Fe_2O_3 + 2B = B_2O_3 + 6FeO.$$

Figure 2 shows the oxidation curves of all melts containing 10% Fe_2O_3 and 2% boron-bearing agent at the tempera-

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[2] Here and elsewhere mass content indicated, unless otherwise specified.

TABLE 1

Melt	Molar content, %			
	Na_2O	CaO	B_2O_3	SiO_2
1	10.0	10.0	53.4	26.6
2	15.0	15.0	70.0	–
3	–	–	40.2	26.8

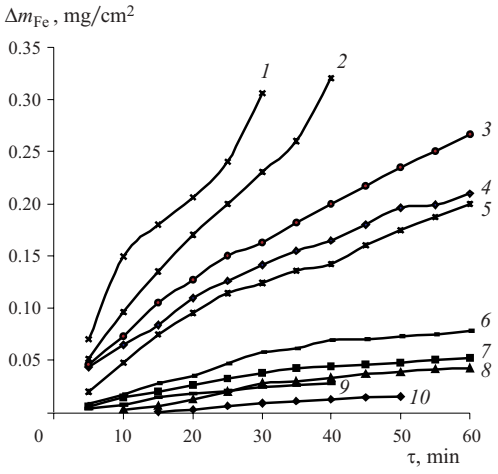

Fig. 1. Dependence of weight loss of sample on treatment duration: *1*) melt 1 + 10% Fe_2O_3; *2*) melt 1 + 5% Fe_2O_3; *3*) melt 1 + 3% Fe_2O_3; *4*) melt 1; *5*) melt 1 + 10% Fe_2O_3 + 2% boron-bearing agent; *6*) melt 1 + 10% Fe_2O_3 + 2% SiN; *7*) melt 1 + 10% Fe_2O_3 + 2% boron-bearing agent; *8*) melt 1 + 2% SiC; *9*) melt 1 + 2% SiN; *10*) melt 1 + 2% boron-bearing agent.

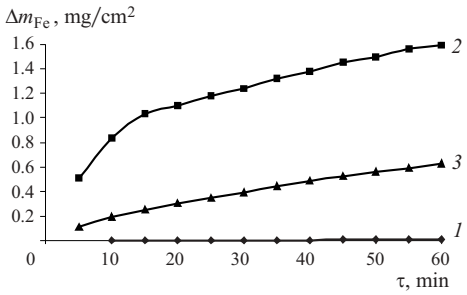

Fig. 2. Oxidation of steel 30KhGSA in the melt containing 10% Fe_2O_3 and 2% boron-bearing product at 1273 K. Curve numbers correspond to the numbers of the melts.

ture of 1273 K. The introduction of 2% boron product produces perceptible crystallization of glass, which prevents using this composition as a glass lubricant for hot rolling. It is found that the quantity of oxidized iron in melt 1 is lower than in the other melts.

Being added to the melt, the deoxidizer reacts not only with iron oxides, but with other oxidizers as well, in particular, with water dissolved in glass:

$$= B - OH + B \rightarrow = B - O - B = + \frac{1}{2} H_2.$$

The experimental data show (Fig. 3) that in iron-free melts the oxidation rate on adding a deoxidizing agent decreases on the average to one-fourth.

In order to determine the optimum amount of the deoxidizer to be added to a melt, the protective properties of melt 1 with 1, 2, and 5 % boron additives were analyzed. It can be seen from Fig. 4 that the optimum content is 2%.

Thus, the introduction of all deoxidizers specified above perceptibly improves the protective properties of glass, however, the best protective properties at the temperature of 1273 K are seen in melt 1 containing 2% boron-bearing deoxidizer.

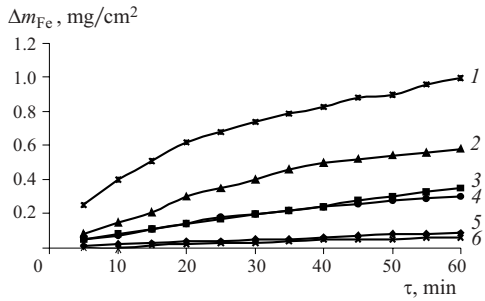

Fig. 3. Oxidation of steel 30KhGSA in the melt deoxidized by silicon nitride or boron-bearing product at 1273 K: *1*) melt 2 + 2% boron-bearing agent; *2*) melt 3 + 2% SiN; *3*) melt 2 + 2% SiN; *4*) melt 3 + 2% boron-bearing agent; *5*) melt 1 + 2% SiN; *6*) melt 1 + 2% boron-bearing agent.

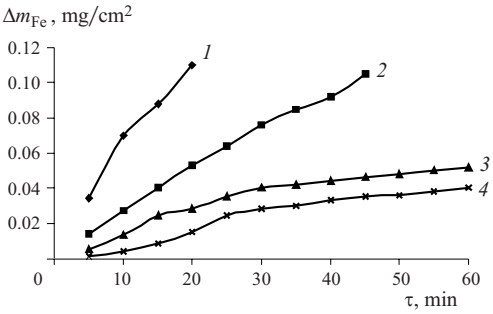

Fig. 4. Oxidation of steel 30KhGSA in melt 1 deoxidized by boron-bearing product at 1273 K: *1*) melt 1; *2*) melt 1 + 1% boron-bearing agent; *3*) melt 1 + 2% boron-bearing agent; *4*) melt 1 + 5% boron-bearing agent.

REFERENCES

1. Yu. V. Manegin and I. V. Anisimova, *Glass Lubricants and Protective Coatings for Hot Processing of Metals* [in Russian], Metallurgiya, Moscow (1978).
2. O. R. Lazutkina and P. I. Buler, "High-temperature protective properties of glass-enamel coatings based on coal ash," *Steklo Keram.*, No. 6, 15 – 16 (2003).